HOW MUCH MELT BRECCIA CAN BE FOUND IN SOUTH POLE-AITKEN BASIN? Noah E. Petro and Carlé M. Pieters, Brown University, Box 1846, Department of Geological Sciences, Brown University, Providence, RI, 02912, USA (e-mail: Noah_Petro@Brown.edu).

Introduction: The South Pole-Aitken (SPA) Basin is the largest, oldest basin on the Moon. The extreme size of the basin, ≤2,500 km in diameter and a present depth of up to 13km [1,2], suggests that much of the upper crust would have been excavated during the formation/impact event, exposing the lower crust or upper mantle. Also, a large volume of impact melt breccia containing extensive lower crust components is also expected to have been created [3, 4].

Samples of the SPA melt breccia can be used to constrain the age of the basin as well as the composition of the lower crust. However, some of the unique features of the SPA basin have been affected by billions of years of subsequent evolution of the lunar surface. While several processes have been active during this time (extensive impact cratering, emplacement of mare basalts, lateral mixing by craters, space weathering, etc.), this abstract will only consider the early emplacement and mixing of basin ejecta within the interior of SPA. Previous work [5] estimated the amount of foreign material that has been introduced into the center of SPA by later basin forming events. We extend these studies to include the interaction and mixing of this ejecta with the surface of the basin. Investigation of these processes allow an estimation of the percent of current surface components that is derived from the original SPA melt breccia.

Approach: The basins used in this study include all identified basins on the same lunar hemisphere of SPA [6]. These basins are shown in Figure 1 and listed in Table 1. The Imbrium basin is also included because it is one of the most recent and largest basins on the Moon.

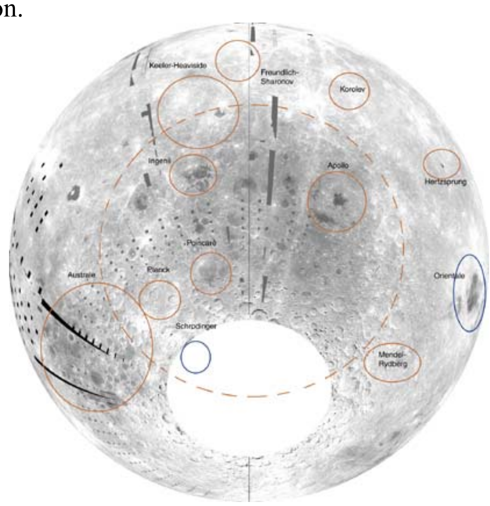

Figure 1. Orthographic projection of SPA hemisphere centered at 56ºS, 180ºE showing the basins used in this study. Wilhelms' ring for SPA [6] is a dashed line.

During emplacement, basin ejecta mixes with the lunar surface, and the degree of mixing varies with distance from the source [7]. Oberbeck et al. [8] calculated the mixing ratio of foreign to local material (μ) based on observations of secondary craters of Copernicus. Independent investigations of foreign/local mixing relationships at a ray of Copernicus [9] and at Orientale cryptomare [10] have shown that the μ ratio calculation determined by [8] was in good agreement with remote sensing observations. The ejecta thickness model of Pike [11] is used here to estimate the thickness of ejecta at a given distance from a crater or basin. An estimate can then be made of the total amount of ejecta that has been introduced into SPA. Shown in Figure 2 are ejecta thickness estimates across 59.5º south from 180º to 150º west for several basins (Table 1). It is recognized that several variables are not controlled in this approximation (symmetric distribution of ejecta, uniform radial distribution, no topographic effects, etc.) but the values in Figure 2 provide a good overview of the relative abundance of debris from external sources. Thickness estimates from basins at or near the limb of the SPA hemisphere were corrected to account for the curvature of the Moon.

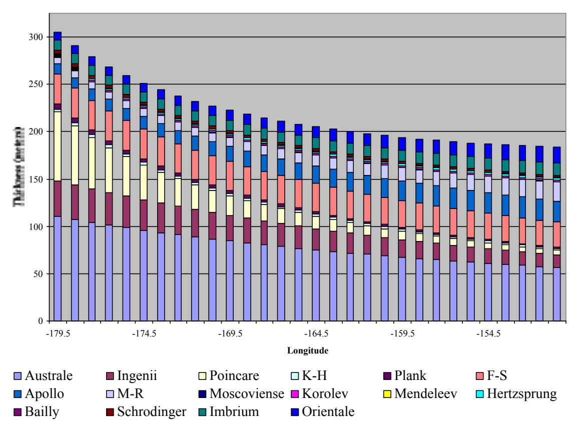

Figure 2. Transect of estimated basin ejecta deposited at 59.5º south from 180º to 150º west. Basins in approximate stratigraphic order [6].

The material that is introduced into SPA mixes with local material at the surface during emplacement. It is assumed that this event creates a homogeneous mixture. The mixing ratio, μ, when combined with the estimated amount of ejecta introduced into the basin defines a depth of mixing and is used to determine the proportion of melt breccia of SPA contained in surface material today. The μ values calculated from [8] for each of the basins range from 27 for Imbrium to 4 for Poincaré and are given in Table 2. If the predicted mixing ratios (μ) are correct, it is important to note that only the relative thickness of basin ejecta into SPA, not the absolute value, is actually important for estimating the current % SPA melt breccia. The absolute thickness values, however, determine the total thickness of the mixed megaregolith.

The ejecta thickness estimates based on [11] was derived from transient crater sizes of basins described by Wieczorek and Phillips [12]. Transient crater sizes not given in Wieczorek and Phillips were estimated based on their approximation using the second innermost ring to estimate the transient crater size. However, when no second innermost ring was present, innermost ring or only present ring was used (i.e. Freundlich-Sharonov). The values used for transient crater are summarized in Table 1.

Haskin et al. [13] estimate that 80% of original SPA material would be found at the present surface at 60º south, 160º west. They use a different method for calculating ejecta thickness and distribution and considered a separate group of basins and craters. Nevertheless, both approaches identify sites with abundant SPA melt breccia in surface materials.

Results. The cumulative thickness of ejecta calculated for a traverse near the center of SPA is shown in Figure 2. Results of mixing calculations for a single location, 59.5º south, 165.5º west are presented in Table 2. This area is a pre-Nectarian region that is located outside several Nectarian-aged craters [14] but is within terrain mapped by [6] as being "Interior Materials of South Pole-Aitken Basin."

The greatest amounts of foreign debris was emplaced by the basins Australe (77 m), Ingenii (23 m), Freundlich-Sharonov (19 m), Apollo (18 m), Poincaré (14 m), and Imbrium (12m). These six basins account for 87% of ejecta emplaced at the study location for the basins examined.

With each successive emplacement event foreign material is added and dilutes the mixed portion of the regolith. Only when ejecta is mixed over a depth greater than that of previous events, as is estimated to have occurred with Freundlich-Sharonov and Imbrium, does the proportion of local SPA material increase. Following the most recent basin event, the emplacement of Orientale ejecta, it is estimated that approximately 59% of surface components is derived from the original SPA melt breccia.

Conclusions: The mixing calculations of Oberbeck [8] and the relative ejecta thickness estimations of Pike [11] has been used to estimate the portion of SPA melt breccia that would be found in the present regolith of SPA. Results are in close agreement with the findings of Jolliff et al. [15] and are somewhat less than that of Haskin et al. [13]. Regardless, more than half of the current SPA regolith is estimated to consist of material derived from the original SPA melt breccia, which would allow for age and composition determinations from future sampling missions. Future considerations of components in SPA regolith will take into account the effects of other basins as well as the mixing effects of smaller nearby craters.

Basin	Main Ring [6]	T.C. [12]	Est. T.C.*	T.C. Used
Australe	880		690	690
Ingenii	325		325	325
Poincaré	340		175	175
K-H	270		270	270
Plank	325		175	175
F-S	600		600	600
Apollo	505		250	250
M-R	460	281 (±21)		281
Moscov.	445		210	210
Korolev	220		220	220
Mendeleev	140		140	140
Hetrzsprung	570		265	265
Bailly	300		150	150
Schrodinger	320		155	155
Imbrium	1160	744 (±37)		744
Orientale	930	397 (±10)		397

Table 1. Transient crater diameters (in kilometers) used in this study. *Estimation based on main ring or approximation [12] of second-innermost ring. Basins are listed in approximate age sequence [6].

Basin	Ejecta Thickness (m)	μ value	Depth of Mixing (m)	Cum. % SPA
Australe	77	11	847	91
Ingenii	23	7	174	79
Poincaré	14	4	60	60
K-H	2	12	27	55
Plank	3	7	18	47
F-S	30	16	479	80
Apollo	18	6	106	66
M-R	11	9	99	59
Moscov.	.27	19	5	56
Korolev	2	12	19	53
Mendeleev	.09	16	1	50
Hertzsprung	2	14	26	51
Bailly	1	9	5	45
Schrodinger	2	6	14	47
Imbrium	11	27	311	64
Orientale	12	13	151	59

Table 2. Calculated ejecta thicknesses [11] for basins used, associated μ value [8], resulting depth of vertical mixing, and the predicted amount of SPA melt breccia at 59.5º south, 165.5º west.

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